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SMPTE STANDARD

for Digital Television Tape Recording — 12.65-mm Type D-10 Format for MPEG-2 Compressed Video — 525/60 and 625/50



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1 Scope

This standard specifies the formatting for the recording of data blocks containing MPEG-2 compressed video, multiple channels of AES3 audio, and associated data which form helical records on 12.65-mm (0.5-in) tape in cassettes. This standard also defines the helical track record parameters, the content and format of the longitudinal records, and the cassette physical specifications.

The compressed video uses the MPEG-2 compression which is defined by ISO/IEC 13818-2, with constraints as defined by the associated SMPTE 356M. The compressed video channel supports frame frequencies of 30/1.001 Hz (hereafter referred to as 525/60) and 25 Hz (hereafter referred to as 625/50).

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent edition of the standards indicated below.

AES3-1992, Digital Audio Engineering — Serial Transmission Format for Two-Channel Linearly Represented Digital Audio Data

ANSI/SMPTE 259M-1997, Television — 10-Bit 4:2:2 Component and 4fsc Composite Digital Signals — Serial Digital Interface

SMPTE 12M-1999, Television, Audio and Film — Time and Control Code

SMPTE 326M-2000, Television — SDTI Content Package Format (SDTI-CP)

SMPTE 331M-2000, Television — Element and Metadata Definitions for SDTI-CP

SMPTE 356M-2001, Television — Type D-10 Stream Specifications — MPEG-2 4:2:2P@ML for 525/60 and 625/50

SMPTE RP 204-2000, SDTI-CP MPEG Decoder Templates

IEC 61213 (1993-11), Analogue Audio Recording on Video Tape — Polarity of Magnetization

IEC 61237-1 (1994-06), Broadcast Video Tape Recorders — Methods of Measurement — Part 1: Mechanical Measurements

ISO/IEC 13818-2:2000, Information Technology — Generic Coding of Moving Pictures and Associated Audio Information: Video

3 Abbreviations and acronyms

For the purposes of this standard, the following abbreviations and acronyms apply:

AUX: Auxiliary
DCT: Discrete cosine transform
ECC: Error correcting code
EOB: End of block
I-NRZI: Interleaved nonreturn to zero inverted
MUX: Multiplex
VLC: Variable length coding

4 Environment and test conditions

Tests and measurements made on the system to check the requirements of this standard shall be carried out under the following conditions:

- Temperature: $20^{\circ}\text{C} \pm 1^{\circ}\text{C}$
- Relative humidity: $50\% \pm 2\%$
- Barometric pressure: 86 kPa to 106 kPa
- Tape tension: $0.3 \text{ N} \pm 0.05 \text{ N}$
- Tape conditioning: Not less than 24 h

4.1 Calibration tape

Calibration tapes meeting the tolerances as specified below should be made available by manufacturers of digital television tape recorders and players in accordance with this standard.

4.2 Record locations and dimensions

Geometrical location and dimensions of the recordings on the tape and their relative positions in regard to timing relations of the recorded signals shall be as specified in figure 27, table 1, and clause 6.2. Tolerances shown in table 1 should, however, be reduced by 50% for calibration tapes.

5 Tape and cassette physical specifications

5.1 Magnetic tape specifications

5.1.1 Base

The base material shall be polyester or equivalent.

5.1.2 Tape width and width fluctuation

The tape width shall be $12.650 \text{ mm} \pm 0.01 \text{ mm}$. Tape width fluctuation shall not exceed $6 \text{ }\mu\text{m}$ peak to peak. The value of tape width fluctuation shall be evaluated by measuring 10 points, each 20 mm apart, over a tape length of 200 mm.

5.1.3 Tape thickness

The tape thickness shall be from $12.3 \text{ }\mu\text{m}$ to $14.5 \text{ }\mu\text{m}$.

5.1.4 Offset yield strength

The offset yield strength shall be greater than 15 N.

5.1.5 Magnetic coating

The magnetic tape used shall have a coating of metal particles or equivalent, longitudinally oriented. The coating coercivity shall be in the range of 118,000 A/m to 136,000 A/m, with an applied field of 800,000 A/m (10,000 oersted), as measured by a 50- or 60-Hz BH meter or vibrating sample magnetometer (VSM).

5.2 Cassette specifications

5.2.1 Cassette dimensions

Two sizes of cassettes shall be identified as follows:

S cassette: $96 \times 156 \times 25 \text{ mm}$ (as shown in figures 1 to 13)

L cassette: $145 \times 254 \times 25 \text{ mm}$ (as shown in figures 14 to 26)

5.2.2 Tape length and recording time

Maximum tape length and recording time are recommended as follows:

S cassette: $239 \text{ m} + 2 \text{ m} - 0 \text{ m}$ — 60 minutes for 525/60 and 71 minutes for 625/50

L cassette: $725 \text{ m} + 2 \text{ m} - 0 \text{ m}$ — 184 minutes for 525/60 and 220 minutes for 625/50

5.2.3 Datum planes

Datum plane Z shall be determined by three datum areas, A, B, and C, as shown in figures 3a and 16a. Datum plane X shall be orthogonal to datum plane Z and shall include the centers of datum holes (a) and (b). Datum plane Y shall be orthogonal to both datum plane X and datum plane Z and shall include the center of datum hole (a) as shown in figures 2 and 15.

5.2.4 Tape winding

The magnetic coating side of the magnetic tape shall face outside on both the supply reel and the take-up reel as shown in figures 4 and 17.

5.2.5 Label area and window area

The hatched areas shown in figures 1 and 14 are for the label and window. Labels attached to the cassette shall not protrude above the outside cassette surface plane.

5.2.6 Guiding groove

For correct insertion into the VTR, four guiding grooves for S cassettes as shown in figures 1 and 2, and three guiding grooves for L cassettes, as shown in figure 15, shall be provided.

5.2.7 Safety tab and safety plug for recording inhibition

For S cassettes, a safety plug at the supply reel side and a hole of minimum depth 10 mm from datum plane Z at the take-up reel side shall be provided as shown in figure 2.

For L cassettes, a safety plug shall be provided at the take-up reel side as shown in figure 15.

The safety plug shall not be deformed by 0.3 mm or more when a force of 2.0 N (204 gf) is applied to the center of it, using a 2.5-mm diameter rod (see figures 12 and 25).

5.2.8 Identification holes

Six identification holes (holes 1 to 6) shall be located as specified in figures 2 and 15. For this format, holes 1, 2, 3, and 6 shall be closed. Holes 4 and 5 shall be open.

5.2.9 Reels

The reels shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it.

The locations of the reels, when in the unlocked position, are shown in figures 4 and 17. Dimensions of the reels are shown in figures 6 and 19. The height of the reels is shown in figures 7 and 20.

The reel shall be completely released when the cassette lid is opened 23.5 mm minimum from datum plane Z.

5.2.9.1 Reel spring force

The reels assembled in the cassette shall be pressed by the reel spring with a specified force under the conditions specified in figures 11 and 24. The spring force shall be $1.5 \text{ N} \pm 0.5 \text{ N}$ (153 gf $\pm$ 51 gf) for S cassettes and $3.5 \text{ N} \pm 0.5 \text{ N}$ (357 gf $\pm$ 51 gf) for L cassettes when pressing on a reel 2.4 mm above datum plane Z as shown in figures 11 and 24.

5.2.9.2 Extraction force

The force (F_1 , F_2) required to pull the tape out from the reel shall not exceed 0.17 N (17gf), as specified in figures 13a and 26a.

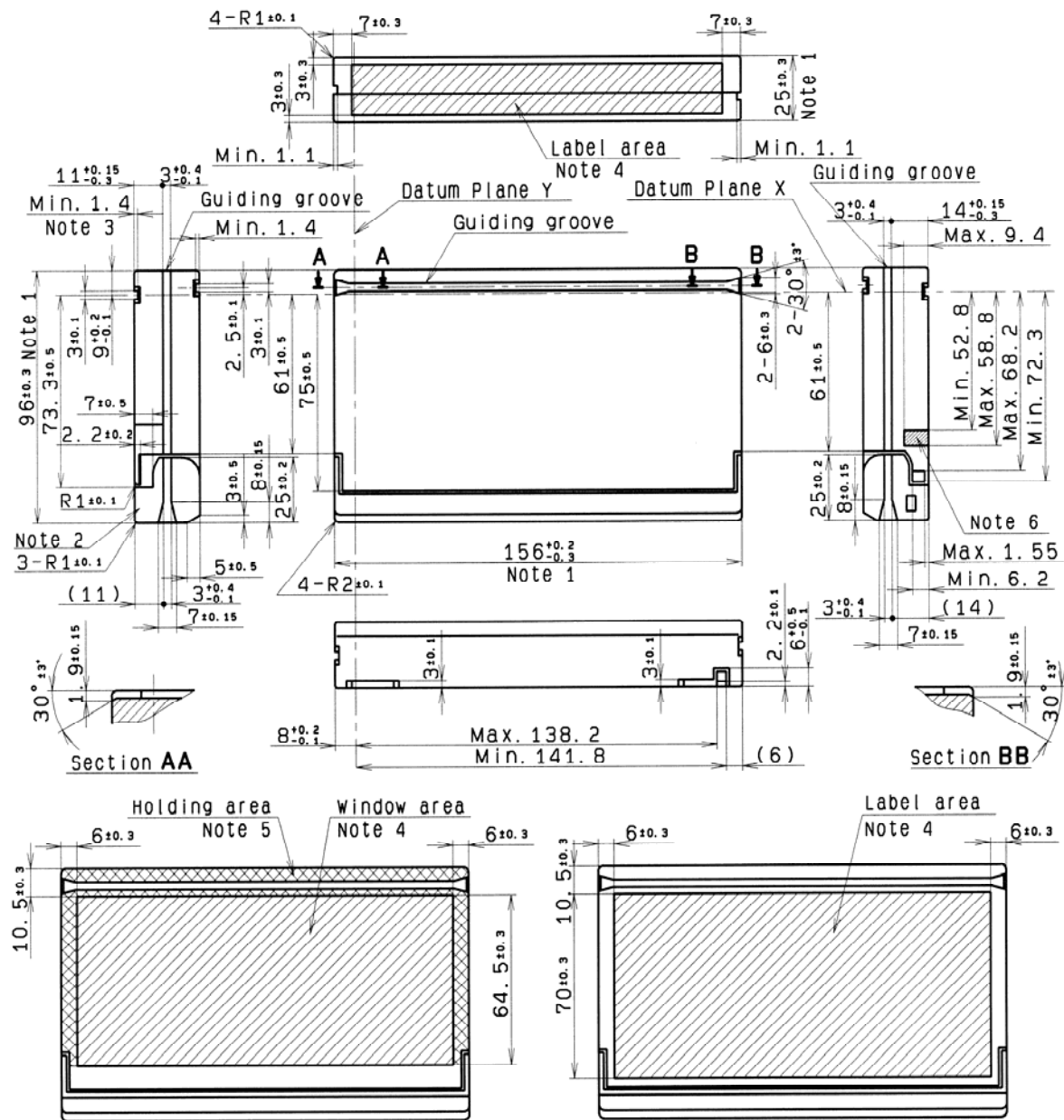
5.2.9.3 Friction torque

The torque required to wind the tape shall be less than 152 m/Nm (152 gf/cm) for S cassettes and less than 30 m/Nm (305 gf/cm) for L cassettes, as specified in figures 13b and 26b.

5.2.10 Protecting lid

The cassette lid shall be automatically unlocked when the cassette is inserted into the video tape recorder and/or player unit and automatically locked when the cassette is ejected from it. The unlocking lever insertion area is specified in figures 8 and 21. The lid shall be unlocked when the lid lock lever is shifted in either direction A or B, as illustrated in figures 9 and 22. The force required to unlock the lid shall be less than 1 N (101 gf) in the A direction or less than 1.5 N (152 gf) in the B direction.

The lid shall open 29.0 mm with a force of 1.5 N (152 gf) or less as specified in figures 10 and 23.



NOTES

- 1 These dimensions are inspected by using limit gauges.
- 2 No part of the lid shall protrude beyond the bottom plane of the cassette when the lid opens or when it closes.
- 3 These dimensions shall be specified based on datum plane Z.
- 4 Label and/or window areas, shown by the hatched area, are available for the label and/or window.
- 5 The cassette may be held in position by the recorder and/or player unit on the holding area shown by the crosshatched area.
- 6 The fine hatched area shows the acceptable range of plug notch position and depth at the side.

Figure 1 – Top and side view dimensions (S-cassette)



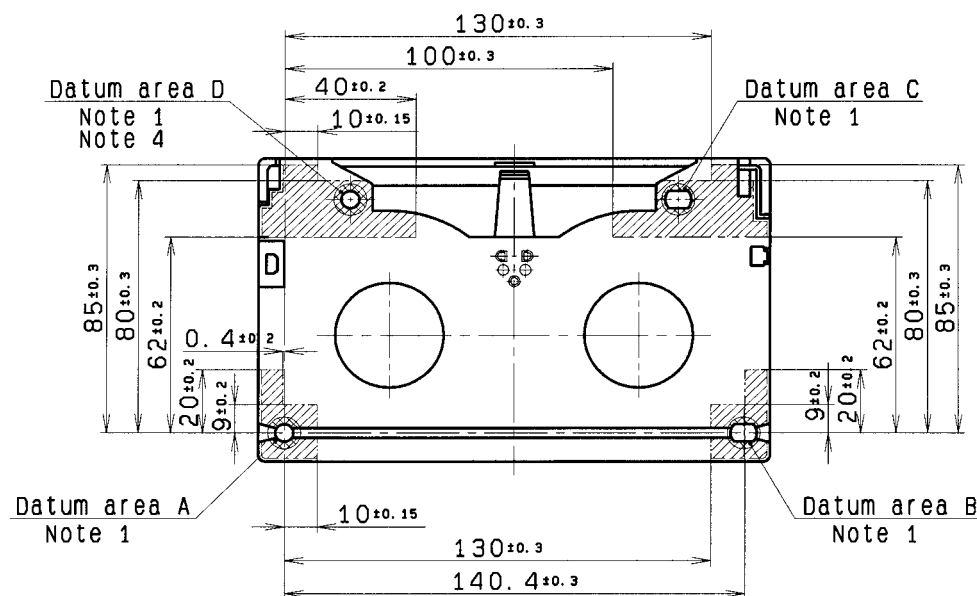


Figure 3a – Datum areas and supporting areas

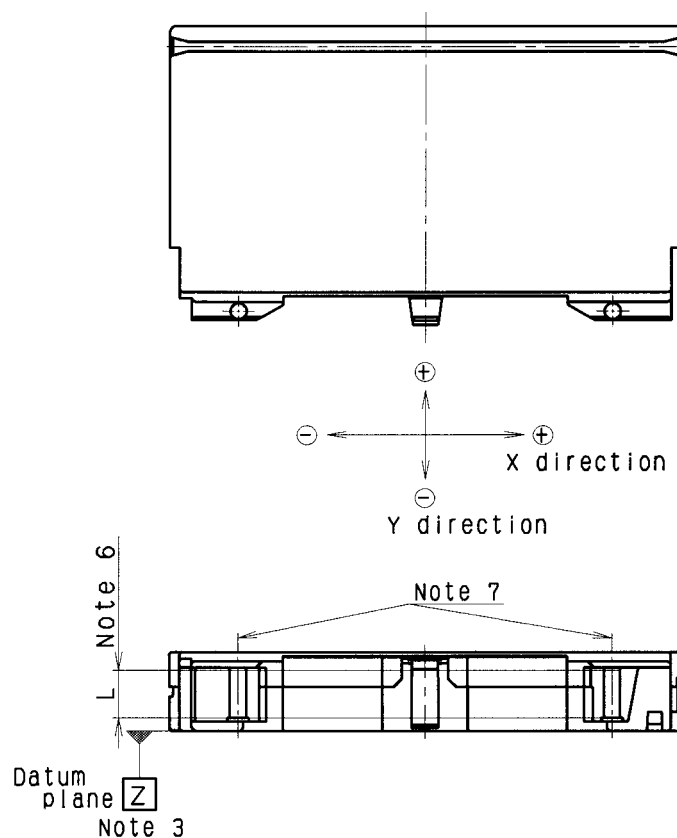


Figure 3b – Tape guides

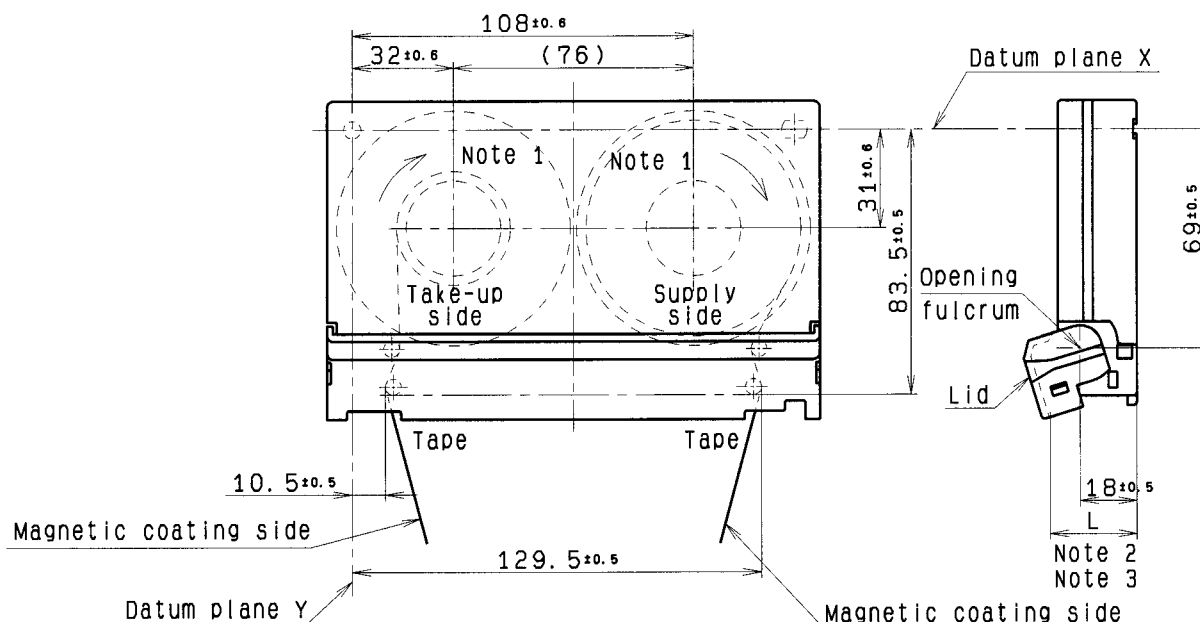
NOTES

- 1 The crosshatched areas 10 mm in diameter are datum areas.
- 2 The four supporting areas, shown by the hatched areas, shall be coplanar with their corresponding datum areas within 0.05 mm of each of them.
- 3 Datum plane Z shall be defined by the three datum areas, A, B, C.
- 4 Datum area D shall be coplanar, within 0.3 mm, with datum plane Z.
- 5 The areas within 1 mm of the edges of a cassette shall not be included in the supporting areas.
- 6 Measurement L: 15 mm.
- 7 Perpendicularity of tape guides is specified as follows (even if they themselves are tapered):

Direction	X	Y
Tape guide		
Supple side	0 ± 0.15	0 ± 0.15
Take-up side	0 ± 0.15	0 ± 0.15

Dimensions in millimeters

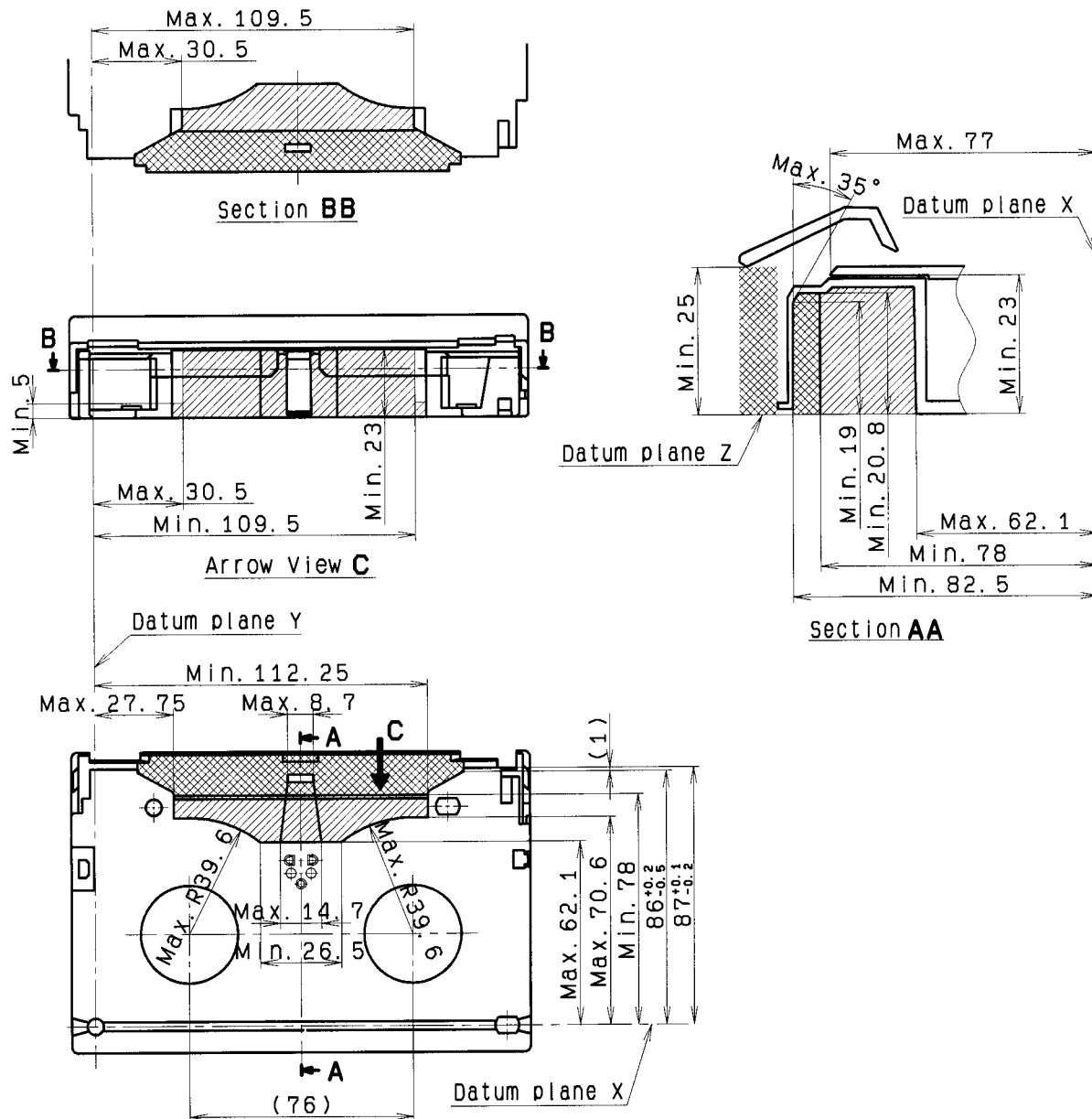
- 1 Direction X: Parallel to the tape running direction.
- 2 Direction Y: Horizontally orthogonal to direction X.

Figure 3 – Datum areas, supporting areas, tape guides and associated dimensions (S-cassette)

NOTES

- 1 The rotating direction of reels during forward operation.
- 2 The lid opening height L shall be 29 mm or more.
- 3 The reel shall be reset completely when the lid opening height L is 23.5 mm.

Figure 4 – Reel location in the unlocked position (S-cassette)

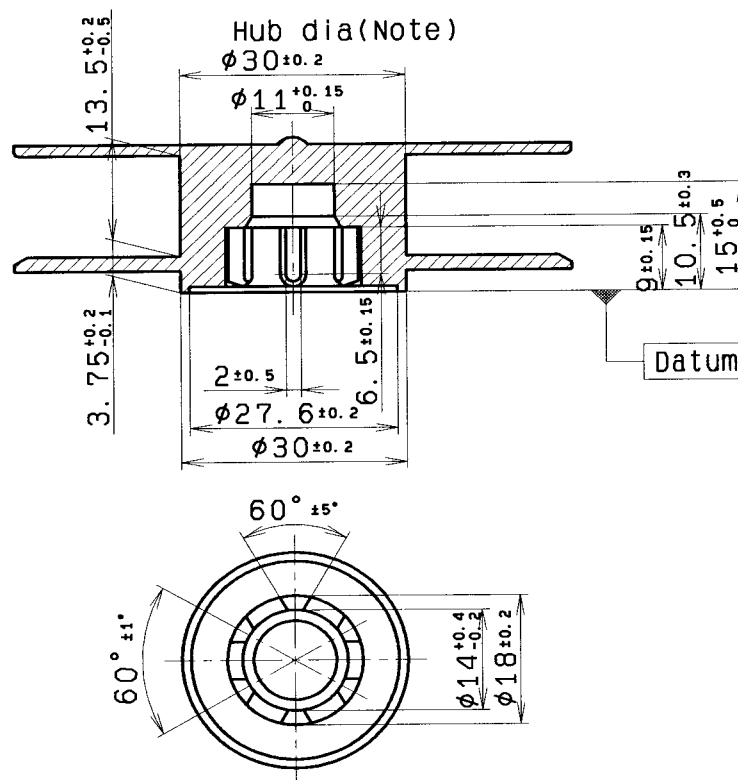


NOTES

1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.

2 The hatched and crosshatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

**Figure 5 – Protecting lid dimensions (S-cassette)
(Minimum space for loading mechanism)**



NOTE – The reels with large hubs (hub diameter 53.3 $\pm$ 0.2 mm) can be used for cassettes whose recording time is less than 12 minutes.

Figure 6 – Reel dimensions (S-cassette)

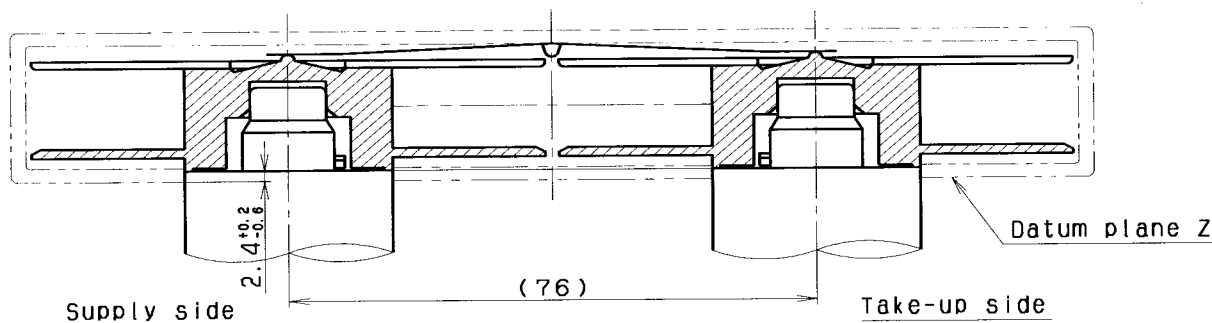
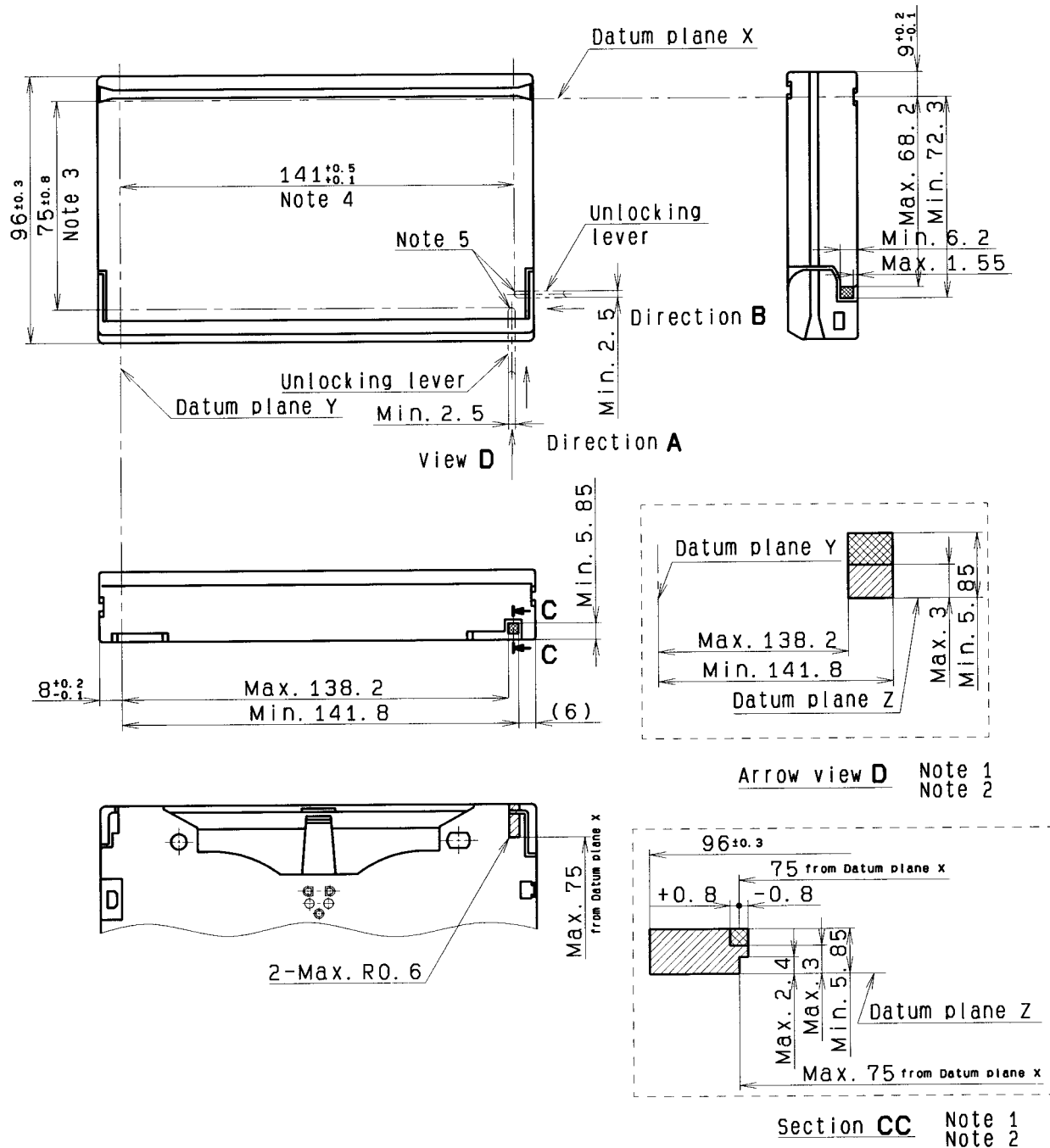


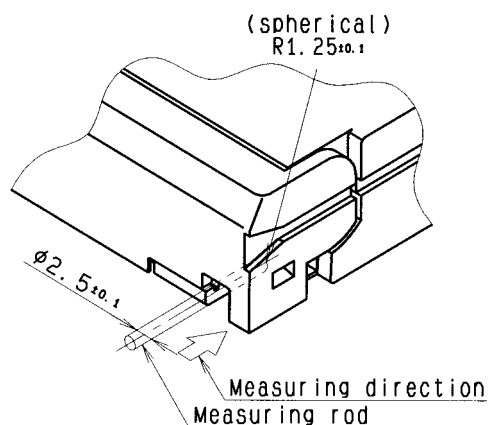
Figure 7 – Reel height in the unlocked position (S-cassette)



NOTES

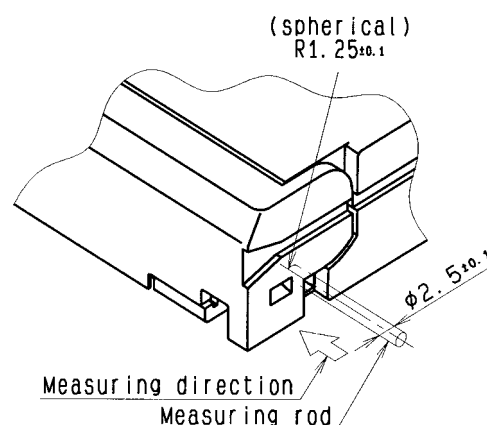
- 1 The crosshatched and hatched areas show the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.
- 2 The crosshatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.
- 3 Allowable range within which the unlocking lever can be inserted in the A direction.
- 4 Allowable range within which the unlocking lever can be inserted in the B direction.
- 5 The tip of the unlocking lever shall be shaped into a semicircle or hemisphere whose radius is half of the unlocking lever width.

Figure 8 – Unlocking lever insertion area (S-cassette)



Direction A – The force to unlock the lid shall not be greater than 1.0 N in the A direction.

Refer to Figure 8 regarding the measuring ranges.



Direction B – The force to unlock the lid shall be less than 1.5 N in the B direction.

Refer to Figure 8 regarding the measuring ranges.

Figure 9 – Lid unlocking force (S-cassette)

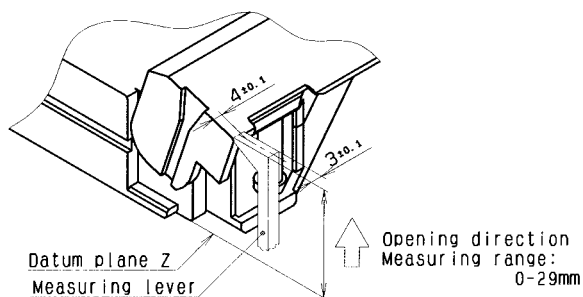


Figure 10 – Lid opening force (S-cassette)

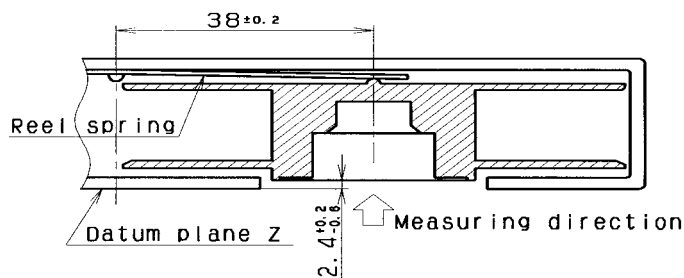


Figure 11 – Reel spring force (S-cassette)

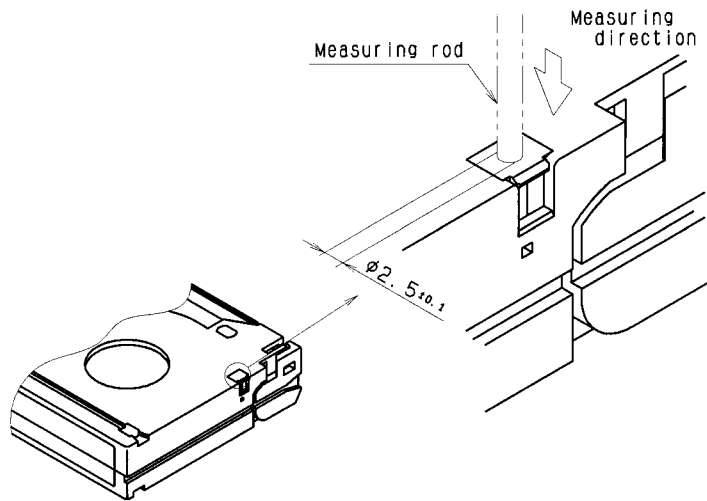


Figure 12 – Safety plug strength (S-cassette)

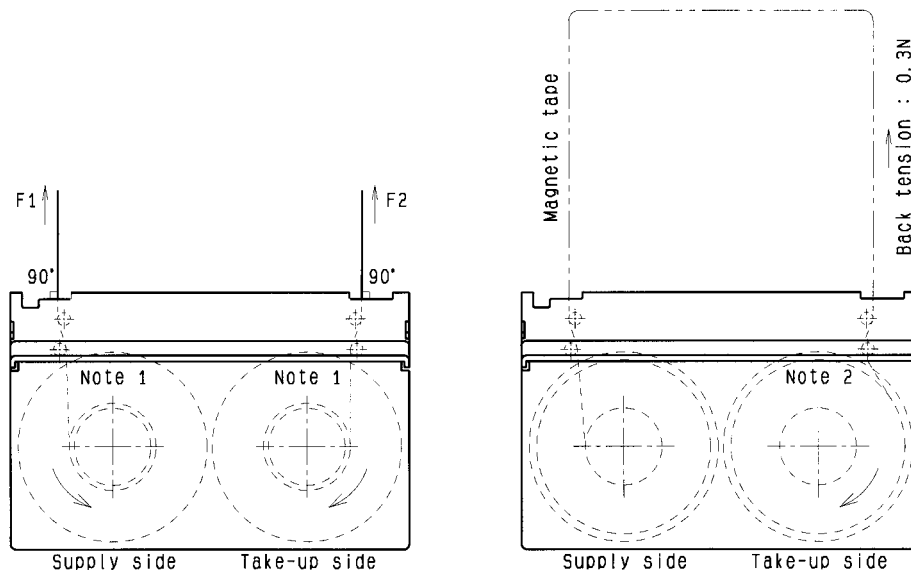


Figure 13a – Extraction force (F1, F2)

Figure 13B – Friction torque

NOTES

- 1 Holdback torque of 1 m/Nm.
- 2 Friction torque to wind the tape.

Figure 13 – Extraction force (F1, F2) and friction torque (S-cassette)

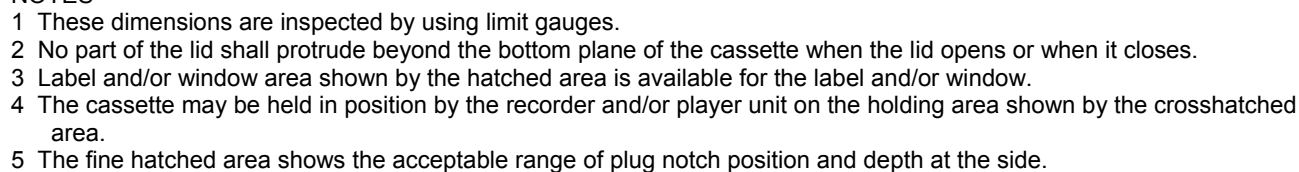
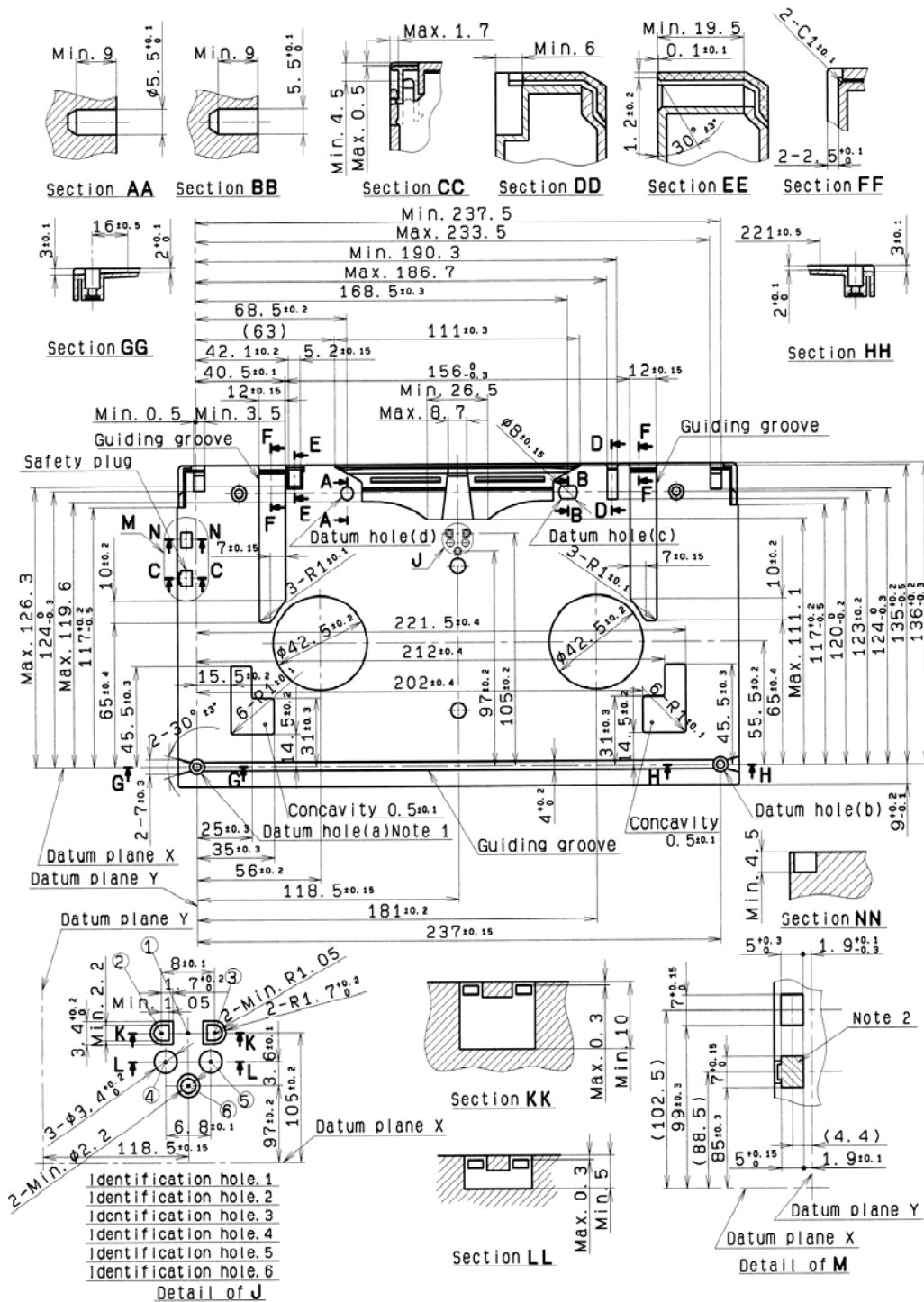


Figure 14 – Top and side views (L-cassette)



NOTES

- 1 Datum hole (a) is primary.
- 2 The crosshatched area shows the VTR detection area.
- 3 Datum holes (a) and (b) may be utilized for screw holes.

Figure 15 – Bottom view (L-cassette)

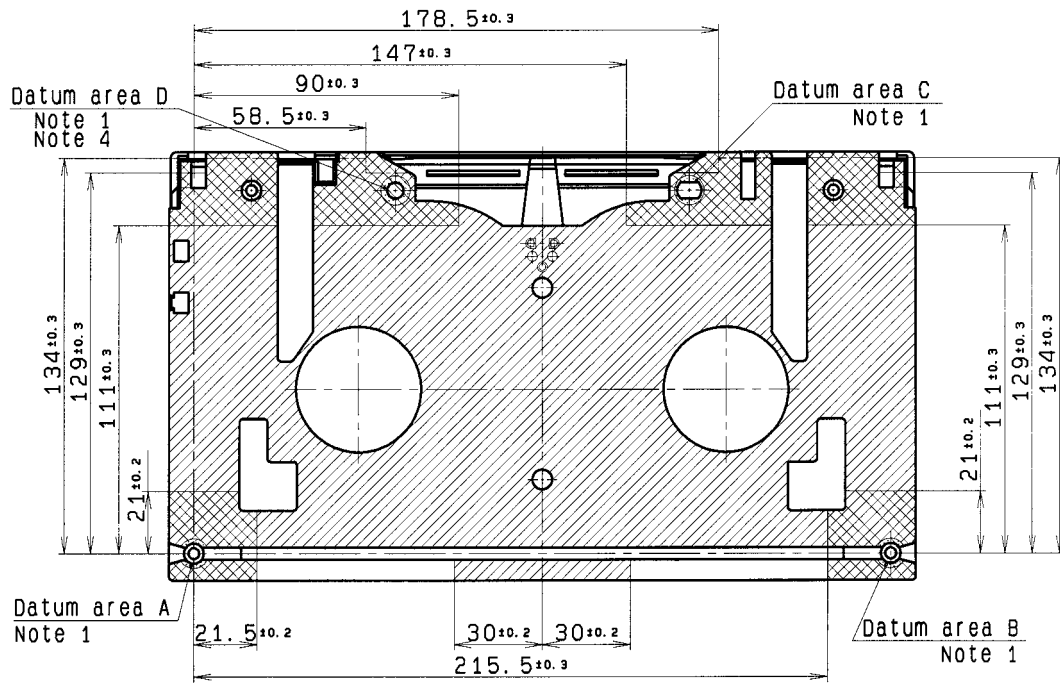


Figure 16a – Datum areas and supporting areas

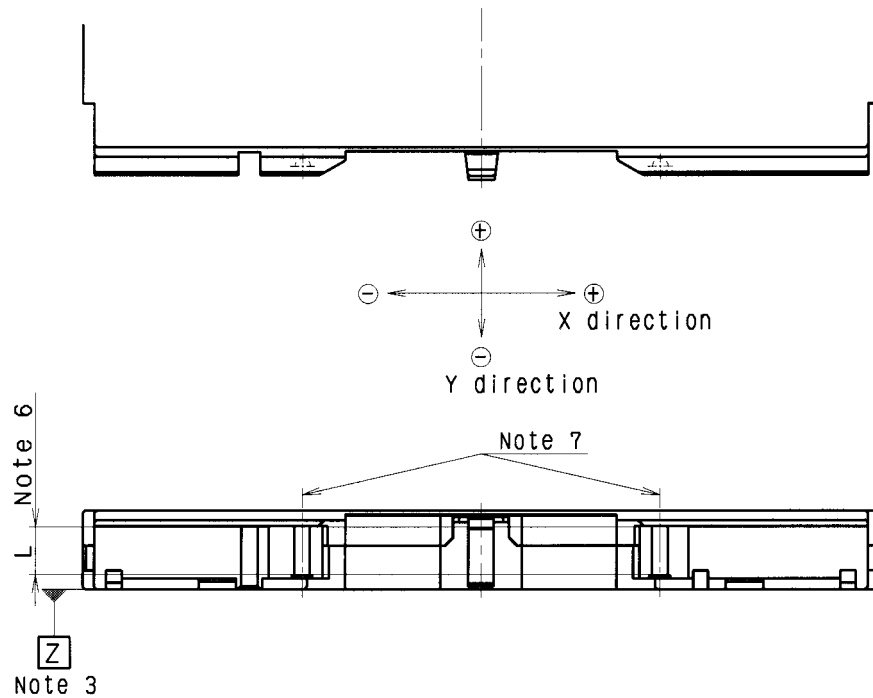


Figure 16b – Tape guides

NOTES

- 1 The four round areas 10 mm in diameter are datum areas.
- 2 The four supporting areas, shown by the crosshatched areas, shall be coplanar with their corresponding datum areas within 0.05 mm of each of them and shall be coplanar with the hatched areas.
- 3 Datum plane Z shall be defined by the three datum areas, A, B, C.
- 4 Datum area D shall be coplanar within 0.3 mm with datum plane Z.
- 5 The areas within 1 mm of the edges of the cassette shall not be included in the supporting areas.
- 6 Measurement L: 15 mm.
- 7 Perpendicularity of tape guides is specified as follows (even if they themselves are tapered):

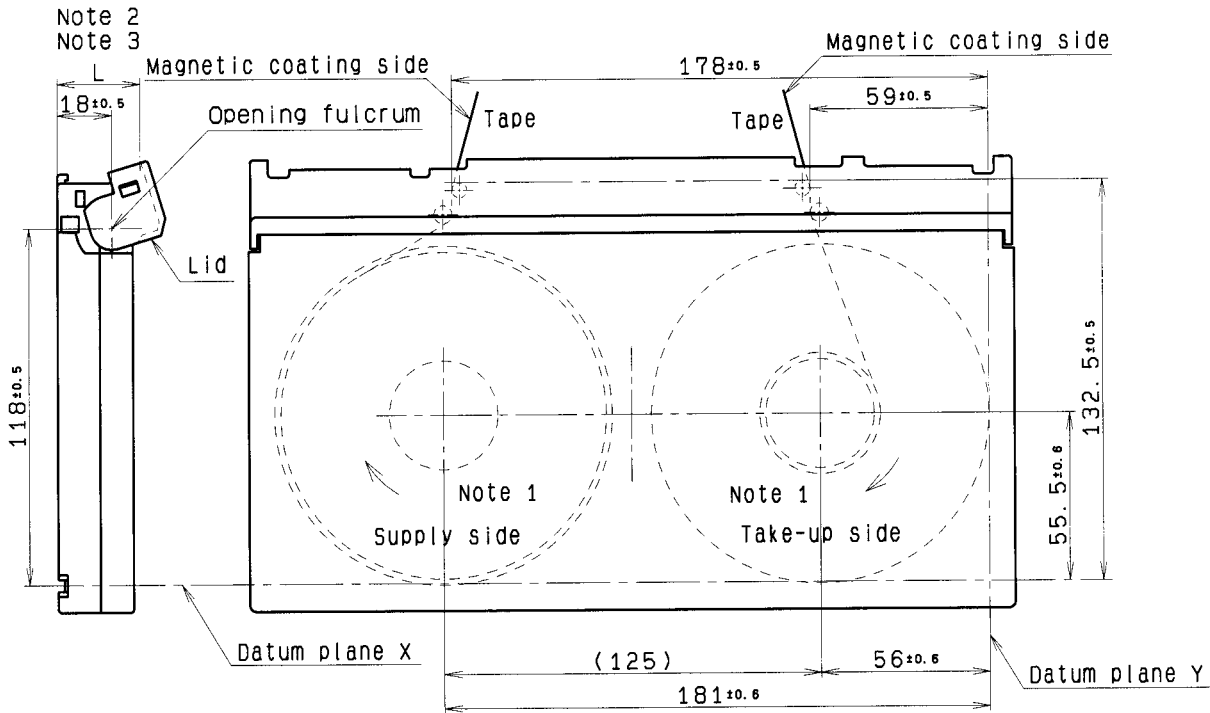
Direction	X	Y
Tape guide		
Supply side	0 ± 0.15	0 ± 0.15
Take-up side	0 ± 0.15	0 ± 0.15

Dimensions in millimeters

NOTES

- 1 Direction X: Parallel to the tape running direction.
- 2 Direction Y: Horizontally orthogonal to direction X.

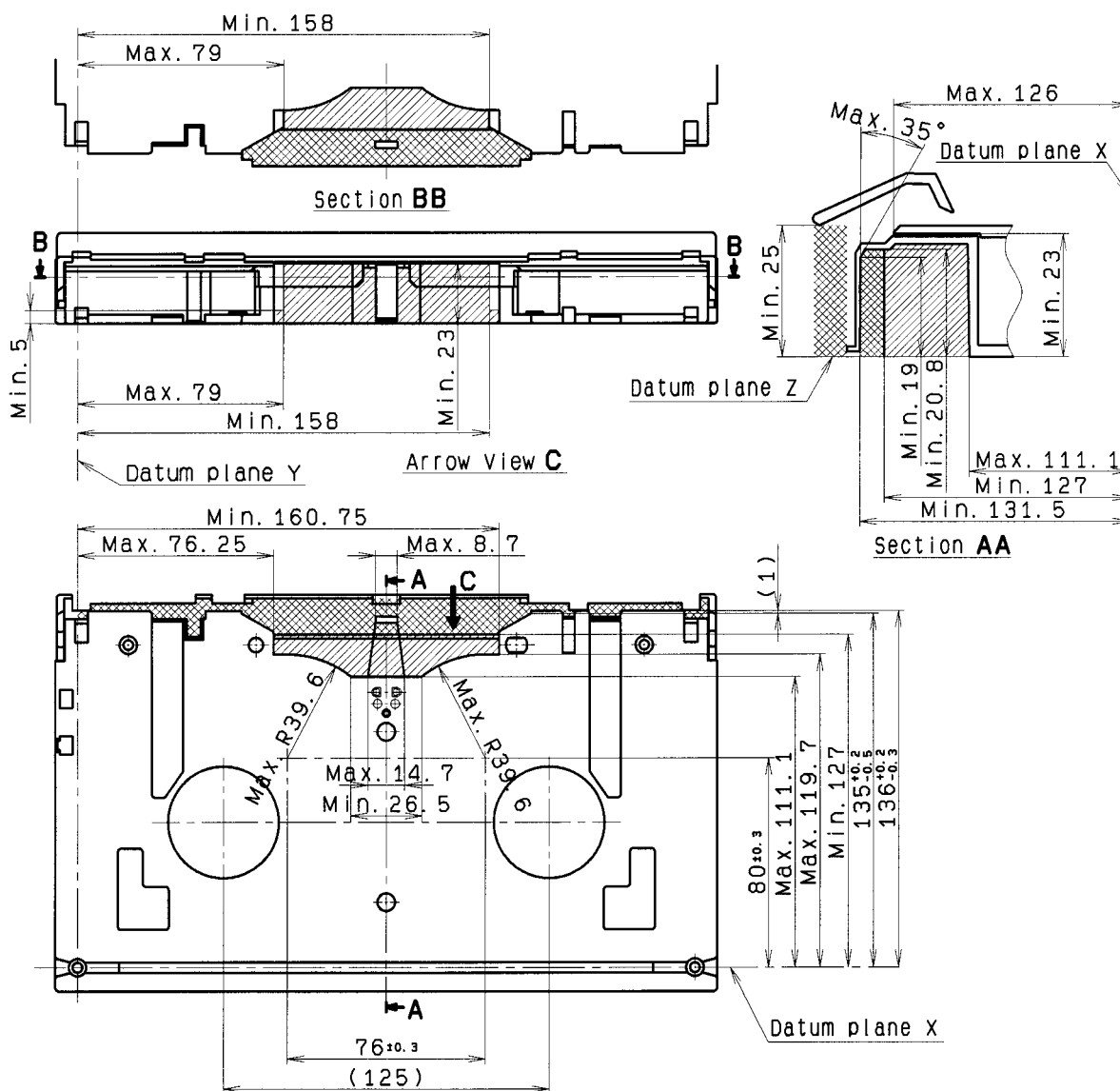
Figure 16 – Datum areas, supporting areas and tape guides (L-cassette)



NOTES

- 1 The rotating direction of reels during forward operation.
- 2 The lid opening height L shall be 29 mm or more.
- 3 The reel shall be reset completely when the lid opening height L is 23.5 mm.

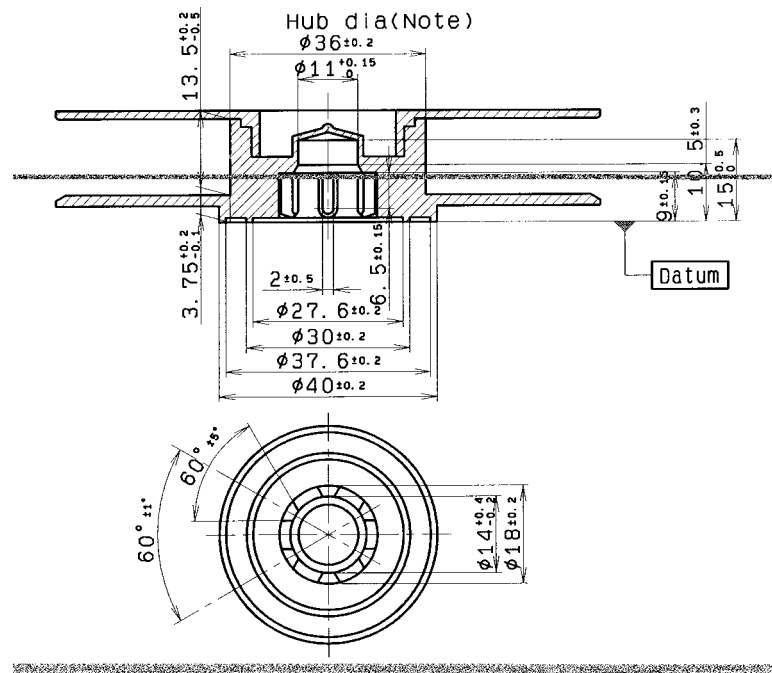
Figure 17 – Reel location in unlocked position (L-cassette)



NOTES

- 1 The hatched area is where the loading mechanism of the video tape recorder and/or player unit positions the video cassette when it is inserted.
- 2 The hatched and crosshatched areas are so designed that the loading mechanism of the video tape recorder and/or player unit unwinds and extends the magnetic tape towards the head drum after the lid opens.

Figure 18 – Protecting lid (L-cassette)
(Minimum space for loading mechanism)



NOTE – Reels with large hubs (hub diameter 53.3 mm ± 0.2 mm) can be used for cassettes whose recording time is less than 34 minutes.

Figure 19 – Reel dimensions (L-cassette)

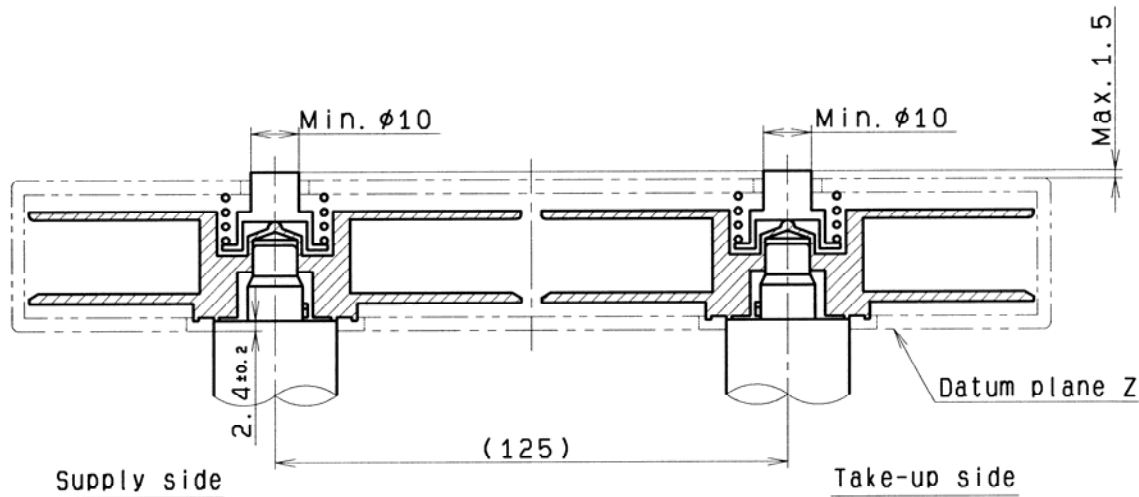
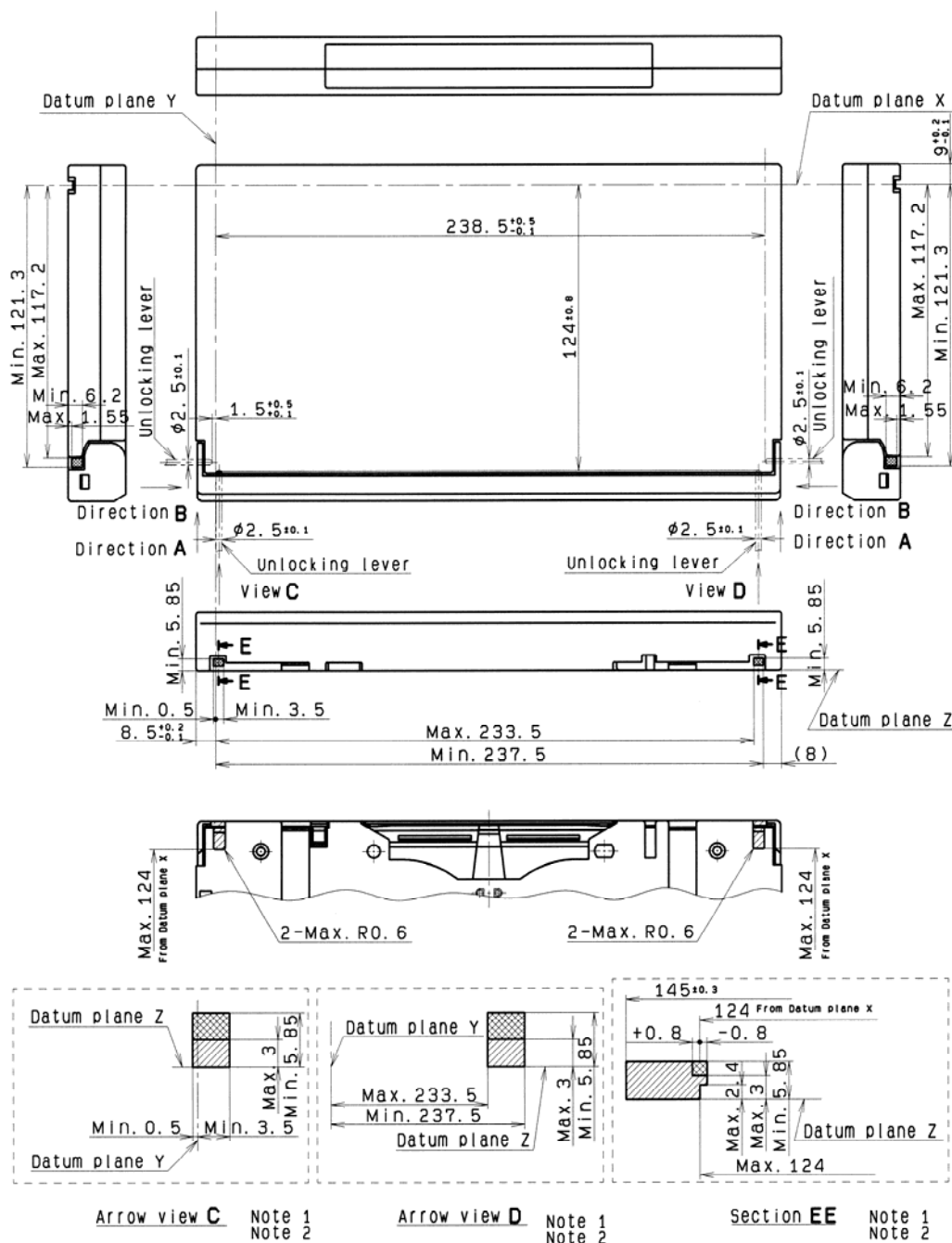


Figure 20 – Reel height in unlocked operation (L-cassette)



NOTES

- 1 The crosshatched and hatched areas show the allowable total area where the unlocking lever extending from the video tape recorder and/or player unit can be inserted into a cassette.
- 2 The crosshatched area shows the range of the unlocking lever insertion which permits the lid to be unlocked.
- 3 Allowable range within which the unlocking lever can be inserted in the A direction.
- 4 Allowable range within which the unlocking lever can be inserted in the B direction.
- 5 The tip of the unlocking lever shall be shaped into a semicircle or hemisphere whose radius is half of the unlocking lever width.

Figure 21 – Unlocking lever insertion area (L-cassette)

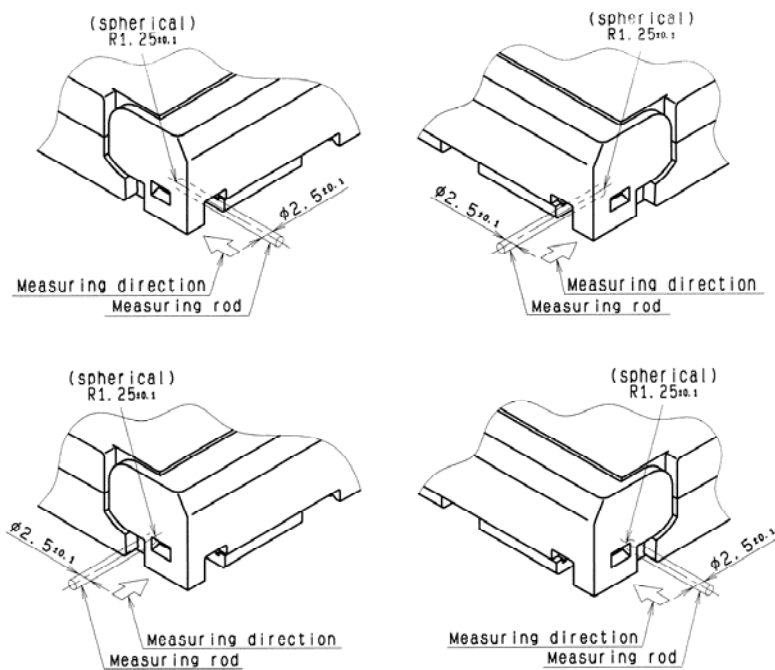


Figure 22 – Lid unlocking force (L-cassette)

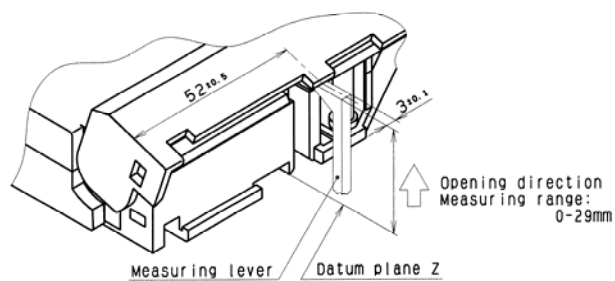


Figure 23 – Lid opening force (L-cassette)

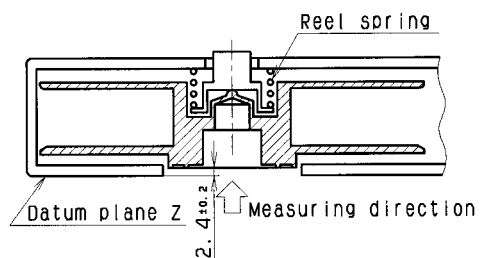


Figure 24 – Reel spring force (L-cassette)

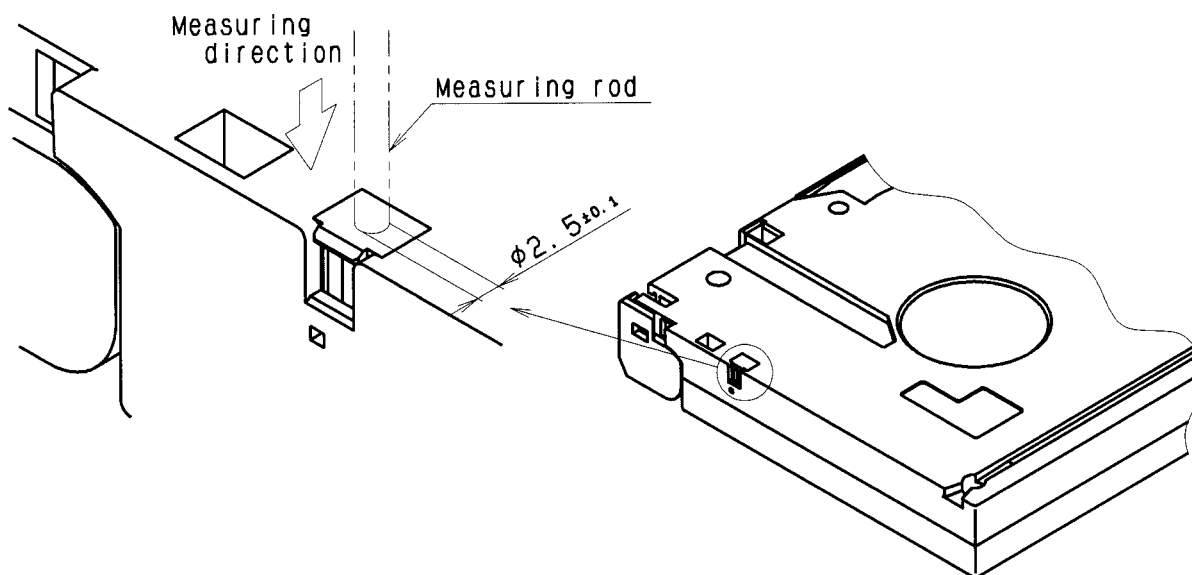


Figure 25 – Safety plug strength (L-cassette)

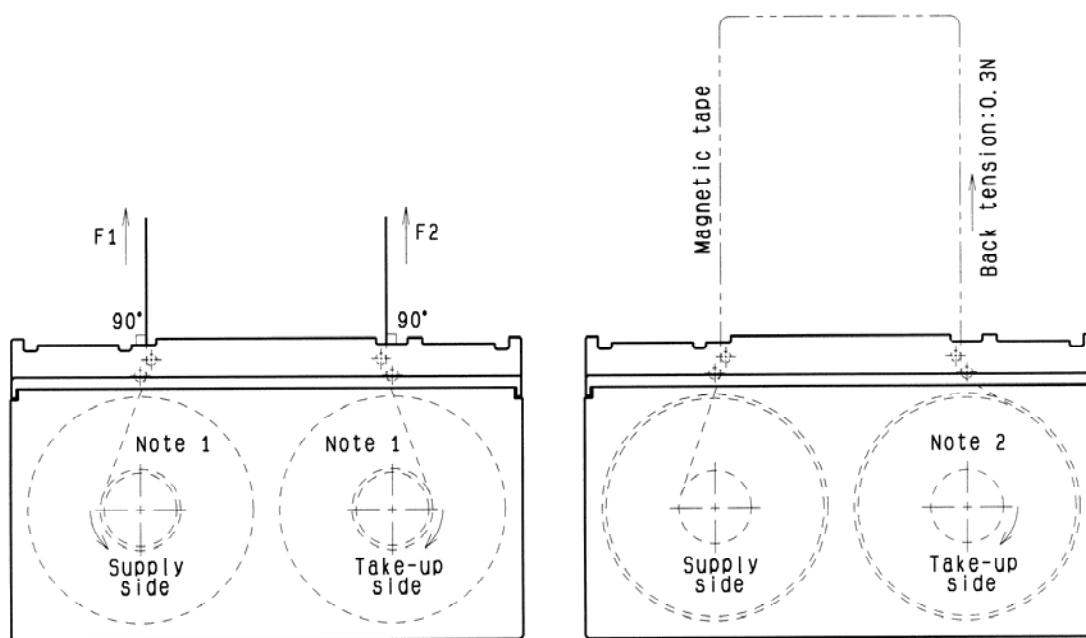


Figure 26a – Extraction force (F1, F2)

Figure 26B – Friction torque

NOTES

- 1 Holdback torque of 1 m/Nm.
- 2 Friction torque to wind the tape.

Figure 26 – Extraction force (F1, F2) and friction torque (L-cassette)

6 Tape record physical parameters

6.1 Tape speed

The tape speed shall be 64.467 mm/s for the 525/60 system or 53.776 mm/s for the 625/50 system. The tape speed tolerance shall be $\pm 0.2\%$.

6.2 Helical record physical parameters

6.2.1 Helical record location and dimensions

The reference edge of the tape for the dimensions specified in this standard shall be the lower edge as shown in figure 27. The magnetic coating, with the direction of tape travel, as shown in figure 27, is on the side facing the observer.

The program reference point for each video frame is determined by the intersection of a line which is parallel to the reference edge of the tape at the distance Y from the reference edge and the centerline of the first track in each video frame; that is track 0 of segment 1. The program reference point defines the start of the first video sector in the video frame.

The physical locations and dimensions of the helical recordings on the tape and their relative positions in regard to the time code start bit and the reference edge shall be as specified in figure 27 and table 1.

6.2.2 Helical track record tolerance zones

The lower edges of all four consecutive tracks shall be contained within the pattern of the four tolerance zones defined in figure 28.

Each zone is defined by two parallel lines which are inclined at an angle of 4.62644° with respect to the tape reference edge.

The centerlines of all zones shall be spaced apart by 0.0217 mm. The width of zones 2, 3, and 4 shall be 0.008 mm. The width of zone 1 shall be 0.004 mm. These zones are established to contain track angle errors, track straightness errors, and vertical head offset tolerance.

The measuring techniques are shown in IEC 61237-1.

6.2.3 Helical track gap azimuth

The azimuth angle of the head gaps used for recording the helical tracks shall be at an angle of α_0 or α_1 to the line perpendicular to the helical tracks, as specified in figure 27 and table 1.

The azimuth of the first track of every frame, that is the program reference point, shall be orientated in the counterclockwise direction with respect to the line perpendicular to the track direction when viewed from the side of the tape carrying the magnetic recording.

6.3 Longitudinal record physical parameters

6.3.1 Longitudinal record location and dimensions

The track widths and tolerances of the control and time code tracks shall be as defined in figure 27 and table 1.

6.3.2 Longitudinal track gap azimuth

The azimuth angle of the head gaps used for recording the longitudinal tracks shall be perpendicular to the tracks.

7 Longitudinal track signal and magnetic parameters

7.1 Longitudinal track record parameters

7.1.1 Method of recording

The control track and time code track signals shall be recorded using the hysteretic (nonbias) recording method.

7.1.2 Flux level

The recording level shall be at saturation of the magnetic domains which is defined as that point above which 0.5 dB increase in output level results from 1 dB increase of input level as indicated on an rms reading meter.

7.2 Control track record parameters

7.2.1 Control track pulse period

The control track pulse, at the point of recording, shall be a series of pulses with a period of $16.683 \text{ ms} \pm 6 \mu\text{s}$ (525/60 system) or $20.000 \text{ ms} \pm 6 \mu\text{s}$ (625/50 system) as shown in figure 29 (525/60 system) and figure 30 (625/50 system).

7.2.2 Control track pulse definition

The rising edge of all control track pulses should be timed to coincide with the frame start point of the reference video delayed by $7.0 \text{ H} + 12 \mu\text{s}$.

For 525/60 systems, the frame start point is defined as the midway point of the leading sync edge position which identifies the start of line 4 in an analog video signal.

For 625/50 systems, the frame start point is defined as the midway point of the leading sync edge position which identifies the start of line 1 in an analog video signal.

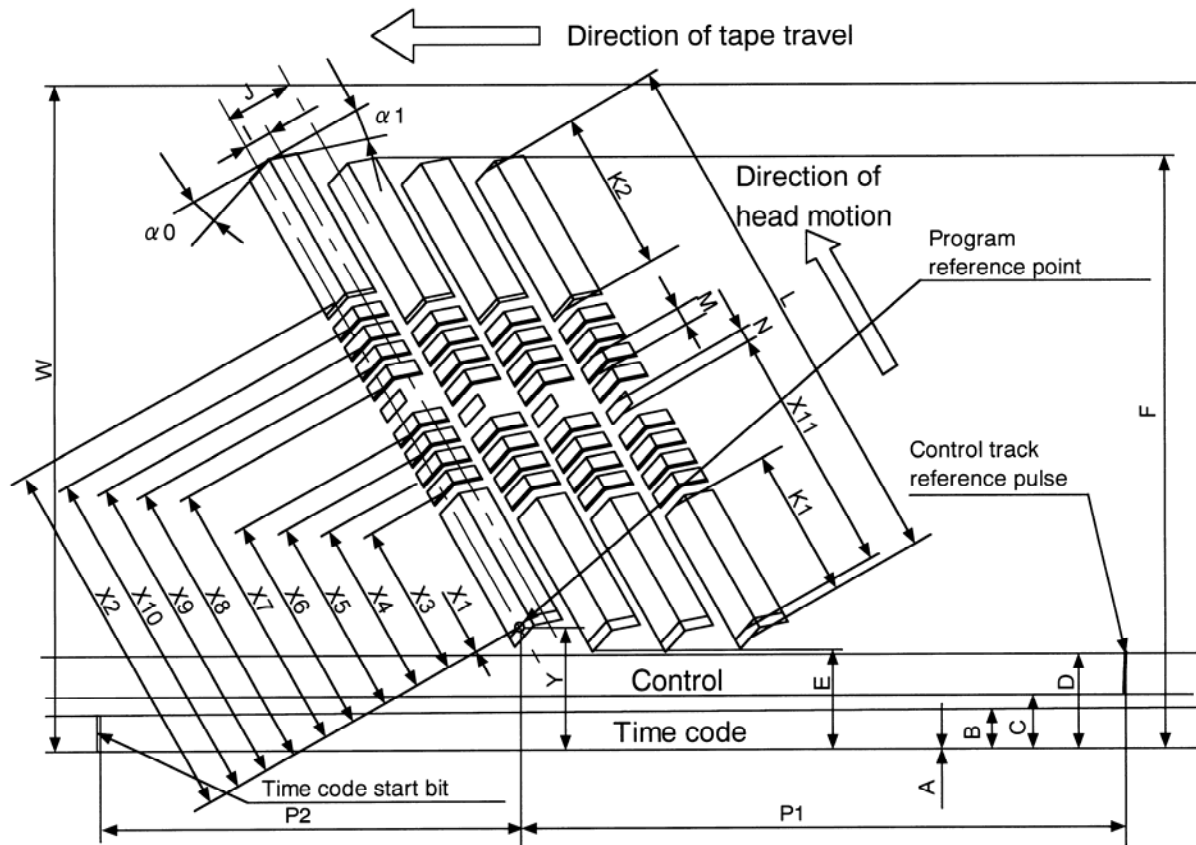
The control track pulses shall have nominal periods of 35T, 50T, or 65T between the rising and falling edges where T is equal to 0.1668 ms (525/60 system) or 0.200 ms (625/50 system) as shown in figure 29 (525/60 system) or figure 30 (625/50 system).

7.2.3 Color frame timing

A color frame sequence at the time of the start of each recording shall be indicated by the leading edges of 65T-width pulses. The color frame commences with color frame A field 1 for the 525/60 system or field 1 for the 625/50 system.

7.2.4 Audio sequence timing

The audio sequence consists of five fields for the 525/60 system as shown in figure 29. A 35T-width pulse indicates the first field of the audio sequence. If the first field coincides with the color frame field, a 65T-width pulse indicates the first field of the audio sequence.



NOTE – Not to scale.

Figure 27 – Locations and dimensions of recorded tracks

Table 1 – Record location and dimensions for 525/60 and 625/50 systems

Dimensions		Dimensions in millimeters		
		Nominal		
		525/60	625/50	Tolerance
A	Time code track lower edge	0	0	Basic
B	Time code track upper edge	0.4	0.4	± 0.065
C	Control track lower edge	0.7	0.7	± 0.065
D	Control track upper edge	1.1	1.1	± 0.065
E	Program area lower edge	2.327	1.597	Derived
F	Program area upper edge	11.465	11.465	Derived
I	Helical track pitch (± azimuth)	0.02	0.02	Ref.
J	Helical track pitch (± azimuth)	0.0434	0.0434	Ref.
K1	Vector sector 1 length	44.11	47.032	Derived
K2	Vector sector 2 length	44.11	47.032	Derived
L	Helical track total length	113.04	122.092	Derived
M	Audio sector length	2.573	2.973	Derived
N	Tracking data area length	1.002	1.002	Derived
P1	Control track reference to program reference	56.249	47.228	± 0.1
P2	TC start bit to program reference	169.775	178.792	± 0.2
W	Tape width	12.65	12.65	± 0.01
X1	Location of start of video sector 0	0	0	± 0.07
X2	Location of start of video sector 1	68.931	75.06	± 0.07
X3	Location of start of audio sector 0	44.635	47.558	± 0.07
X4	Location of start of audio sector 1	47.422	50.745	± 0.07
X5	Location of start of audio sector 2	50.208	53.932	± 0.07
X6	Location of start of audio sector 3	52.994	57.119	± 0.07
X7	Location of start of audio sector 4	57.585	62.111	± 0.07
X8	Location of start of audio sector 5	60.371	65.298	± 0.07
X9	Location of start of audio sector 6	63.158	68.485	± 0.07
X10	Location of start of audio sector 7	65.944	71.673	± 0.07
X11	Location of start of tracking data	56.182	60.708	± 0.07
Y	Program area reference	2.359	1.629	Basic
Dimensions		Angles (°)		
		Nominal		
		525/60	625/50	Tolerance
θ	Track angle	4.62644	4.62644	Basic
α0	Azimuth angle	– 15.269	– 15.269	± 0.17
α1	Azimuth angle	15.231	15.231	± 0.17
NOTE – The above measurements shall be made under the conditions specified in clause 4.				

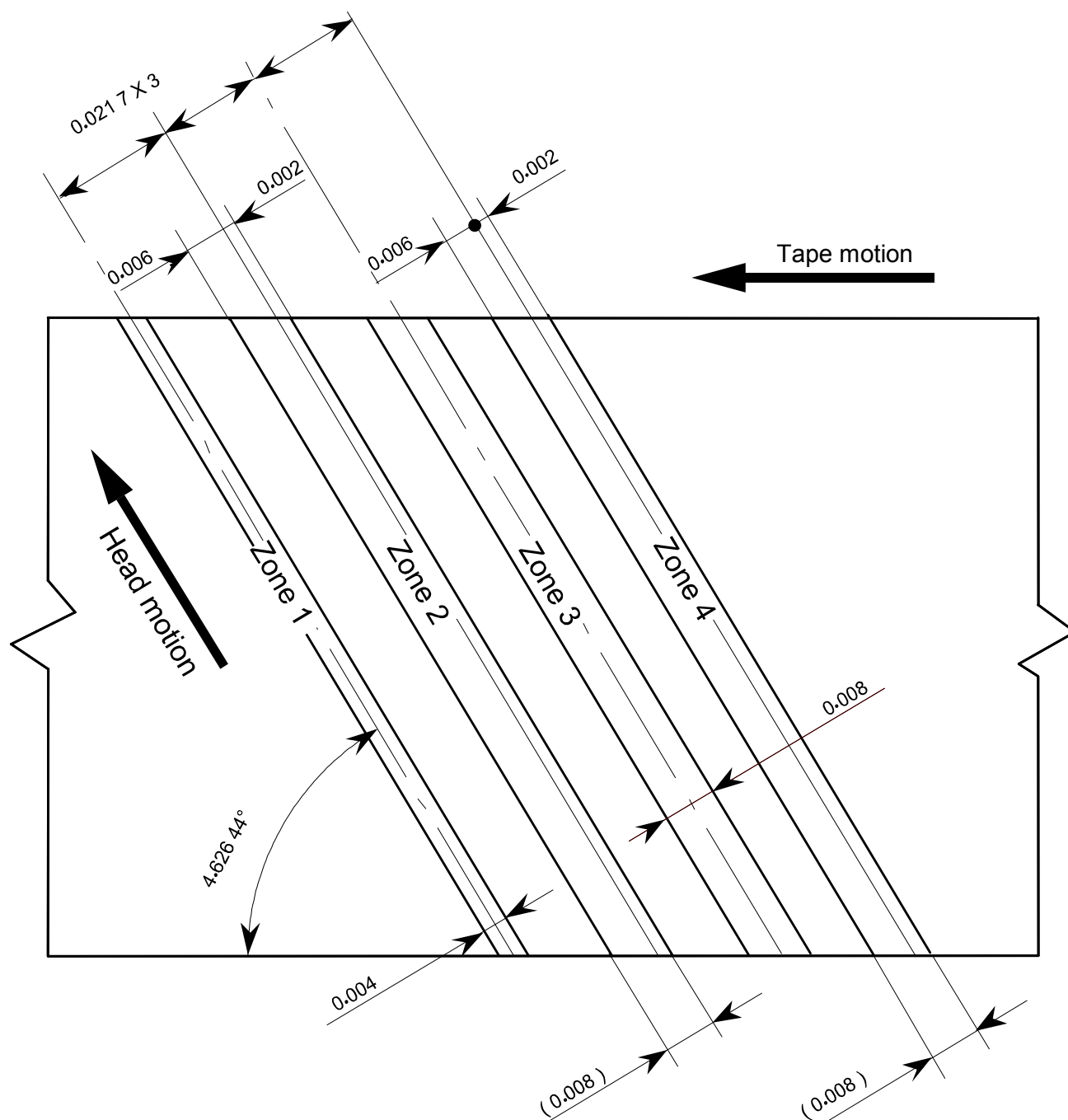
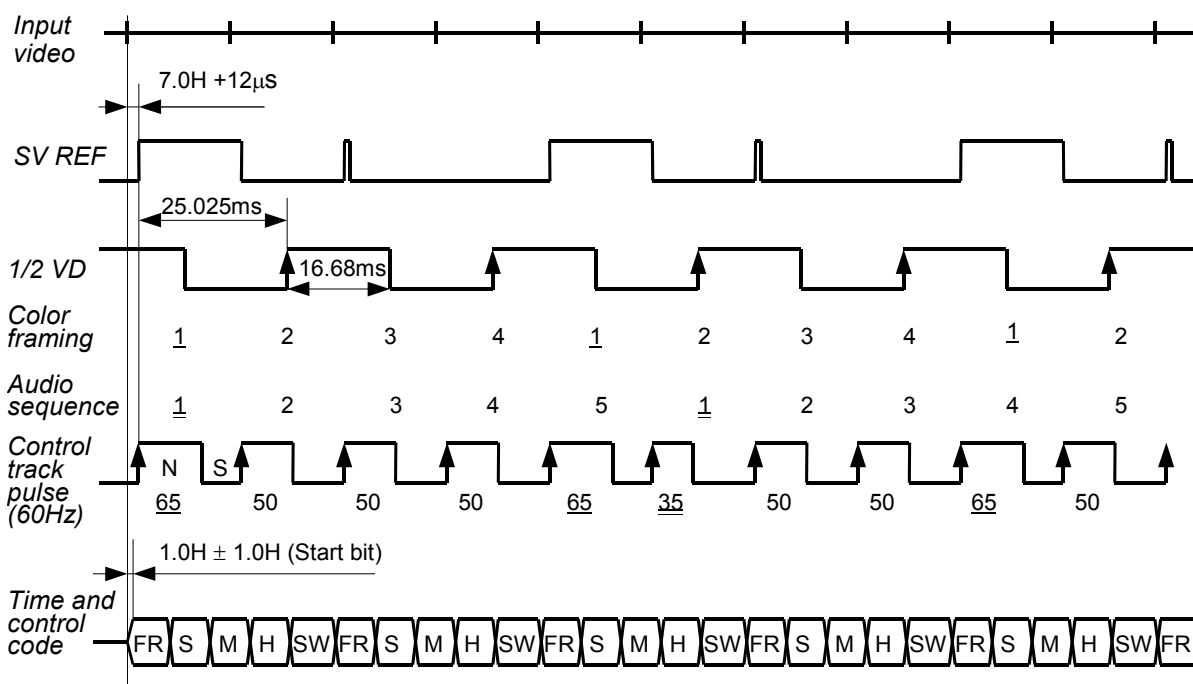
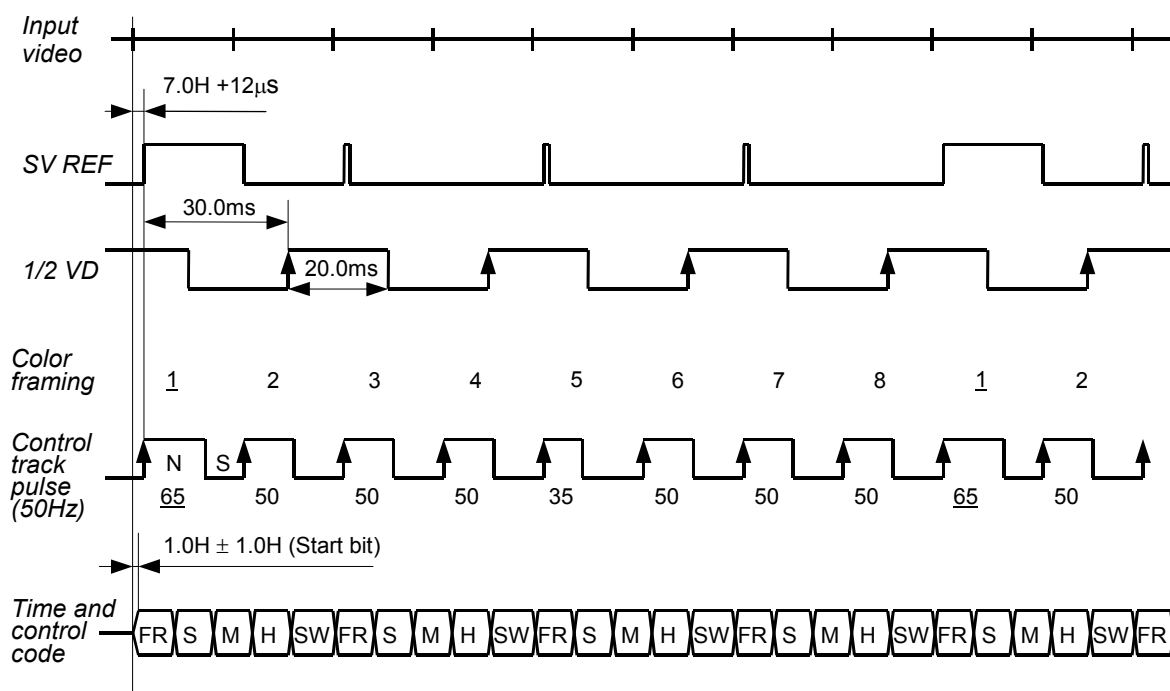


Figure 28 – Location and dimensions of tolerance zones of helical track records



NOTE – The following definitions are used in figures 29 and 30: SV REF: servo reference; 1/2 VD: a half rate vertical drive pulse; FR: frame; S: second; M: minute; H: hour; SW: sync word.

Figure 29 – Recorded control code waveform for 525/60 system



NOTE – See note to figure 29.

Figure 30 – Recorded control code waveform for 625/50 system